

**Utah Center for Water Resources Research
Annual Technical Report
FY 2016**

Introduction

The Utah Center for Water Resources Research (UCWRR) is located at Utah State University (USU), the Land Grant University in Utah, as part of the Utah Water Research Laboratory (UWRL). It is one of 54 state water institutes that were authorized by the Water Resources Research Act of 1964. Its mission is related to stewardship of water quantity and quality through collaboration with government and the private sector.

The UCWRR facilitates water research, outreach, design, and testing elements within a university environment that supports student education and citizen training. The UCWRR actively assists the Utah Department of Environmental Quality (UDEQ), the Utah Department of Natural Resources (UDNR), the State Engineers Office, all 12 local health departments, and several large water management agencies and purveyors in the state with specific water resources problems. In FY 2016, the UWRL expended a total of more than \$9 million in water research support. USGS Section 104 funds administered through the UCWRR accounted for approximately one percent of this total. These funds were used for research addressing water management problems, outreach, information dissemination, strategic planning, water resources, and environmental quality issues in the State of Utah. Three research projects were funded in FY 2016 with USGS 104 funds. These projects are respectively entitled, (1) “Quantification of Groundwater Influences in High Gradient Utah Streams and Rivers,” (2) “Water Strategy Advisory Team: An Assessment of the Envision Utah Process to Improve Water Management,” and (3) “WaterMAPS™ for Promoting Urban Landscape Water Use Efficiency.”

These projects dealt with the following water management issues: (1) Analyzing existing flow and chemical data collected throughout two northern Utah streams to quantify groundwater influences in pristine, mountainous, and urban portions of each watershed and provide fundamental information regarding the temporal variability of exchanges. (2) Evaluating the effectiveness of the Water Strategy Advisory Team created by Utah’s governor to assist with a 50-year water plan for Utah and assessing its value as a template for use in other states and jurisdictions; and (3) Examining patterns of water use and change to promote conservation on managed urban landscapes in Utah cities using WaterMAPS™ and establishing metrics, benchmarks, and policy prescriptions for implementation in water management efforts relative to landscape water use.

Research Program Introduction

Sources, sinks and residence times of solutes within stream networks are critical to characterize and quantify because of their role in biogeochemical processes and water quality. The spatially and temporally variable groundwater exchanges are particularly important in heat and solute fate and transport. Understanding these exchanges can assist in interpreting watershed scale responses; however, they are not clearly defined and are widely recognized in many situations as being complex and difficult to understand. One USGS project investigated groundwater/surface water connectivity or exchanges within northern Utah high-gradient watersheds that originate in pristine mountainous areas but extend to urban areas. This research provides an understanding of groundwater sources, including shallow groundwater contributions that can vary with changes in annual precipitation, deeper groundwater that is expected to be more resilient to a changing climate, and groundwater outflows that will likely remain constant over time. Differentiating between shallow and deeper groundwater flowpaths allows for a better understanding of the resilience of a watershed in a changing climate.

Like other semi-arid states, Utah is facing unprecedented water challenges. Utah's governor created a Water Strategy Advisory Team (WSAT) to assist the state in developing a strategy to develop a "50-year water plan for Utah." The team brought together a group of 38 water managers, elected officials, special interest groups, water attorneys, and academics to collaboratively develop a set of goals and priorities for future water policy, and the group produced a series of process documents and final survey results in August of 2015. A USGS-supported project is employing a qualitative methods application known as "policy assessment" to analyze and assess the WSAT experience and process, determine its effectiveness in achieving stated objectives related to water policy planning in Utah, and recommend way to improve achievement of policy objectives for similar processes in the future.

Landscape water conservation is a priority in Utah and throughout the western US as an important urban water demand management strategy, particularly in areas where outdoor watering uses a significant percentage of municipal water supplies. One USGS-supported project addressed the issue of landscape watering in urban systems and the dynamic interactions of people, water applied through irrigation systems, and urban vegetation by developing and extending the WaterMAPSTM software package to enable spatial and temporal analyses of urban water use patterns. The results can aid cities to assess the appropriateness of landscape water use relative to landscape water need, monitor landscape water use change and determine its causes, and analyze how landscape water use and conservation fit into the overall and long-term management of urban water supply systems.

These projects all involved collaborative partnerships throughout the state with various local, state, and federal agencies.

Quantification of Groundwater Influences in High Gradient Utah Streams and Rivers

Basic Information

Title:	Quantification of Groundwater Influences in High Gradient Utah Streams and Rivers
Project Number:	2016UT200B
Start Date:	3/1/2016
End Date:	2/28/2017
Funding Source:	104B
Congressional District:	UT1
Research Category:	Water Quality
Focus Category:	Water Quantity, Water Quality, Management and Planning
Descriptors:	None
Principal Investigators:	Bethany T. Neilson

Publications

There are no publications.

**“Quantification of Groundwater Influences in High Gradient
Utah Streams and Rivers (104B)”**
2016UT200B
(Neilson)

Problem and Research Objectives:

Sources, sinks and residence times of solutes within stream networks are critical to characterize and quantify because of their role in biogeochemical processes and water quality [e.g., *Covino and McGlynn*, 2007; *Harvey et al.*, 2005]. A key process that must also be considered in many stream systems is the spatially and temporally variable groundwater exchanges [*Becker et al.*, 2004; *Cey et al.*, 1998; *Payn et al.*, 2009; *Woesner*, 2000], which are particularly important in heat [*Conant*, 2004; *Constantz*, 1998] and solute fate and transport [e.g., *Harvey et al.*, 1996]. Understanding these exchanges can assist in interpreting watershed scale responses [*Mallard et al.*, 2014]; however, they are not clearly defined and are widely recognized in many situations as being complex and difficult to understand. Interactions between surface and subsurface flow can occur in the hyporheic zone [*Bencala and Walters*, 1983; *Harvey et al.*, 2005; *Kasahara and Wondzell*, 2003], deeper groundwater, the parafluvial zone, the riparian zone [*Boulton et al.*, 1998], and the alluvial plain [*Covino and McGlynn*, 2007]. Exchange flow paths and residence times can vary significantly [*Harvey et al.*, 2003], ranging from centimeters to hundreds of meters and minutes to years [*Harvey et al.*, 1996], making locations, quantities, and distributions difficult to anticipate and measure.

While some have used modeling calibration approaches to indirectly estimate groundwater influences on heat [e.g., *Becker et al.*, 2004] and solute transport [e.g., *Gooseff and McGlynn*, 2005; *Runkel and Bencala*, 1995], other data centric methods are commonly used to estimate groundwater influences or exchanges [e.g., *Christophersen and Hooper*, 1992; *Pinder and Jones*, 1969]. Recent groundwater exchange studies in Northern Utah have focused efforts on reach scales by using a wide variety of data types [*Schmadel et al.*, 2010; *Schmadel et al.*, 2013], but there is a need for a variable scale investigation of the importance of groundwater gains and losses within additional high gradient streams in the region. As part of the Utah EPSCoR Track 1 National Science Foundation project (iUTAH - innovative Urban Transitions and Aridregion Hydro-Sustainability), the ecologic/climate/hydrologic system in Utah watersheds have been monitored to better understand biophysical and hydrologic processes. As part of this effort, three different watersheds along the Wasatch Front have been instrumented longitudinally from mountain unimpacted areas to urban areas with flow gaging stations, multi-probe water quality sondes, and weather stations. Samples have also been routinely collected to establish representative biogeochemical conditions throughout each watershed. Using these data, the most common direct measurements of net groundwater exchanges have been established through differential gaging. More recently, this has been combined with additional chemical sampling at higher spatial resolution to determine appropriate methods for establishing a more complete understanding of groundwater exchanges and their role on stream water quality and quantity in high-gradient systems in the region.

Along these lines, the overall focus of this research was to investigate groundwater/surface water connectivity or exchanges within northern Utah high-gradient watersheds. This includes portions of the

watersheds in more pristine mountainous areas, but extends to urban areas. The key research questions included:

1. How important are groundwater/surface water interactions for understanding and interpreting surface water quality samples and measurements made at the various iUTAH real time water quality stations within each study watershed?
2. How do these groundwater/surface water interactions change over different spatial and temporal scales?

Methodology:

Detailed flow data were gathered at small spatial scales in a synoptic fashion during different flow conditions in 2014–2015 in both Logan River (five sampling events) and Red Butte Creek (four sampling events). These data were available along the mainstem as well as for tributaries/inflows and diversions. Accounting for these inflows and diversions makes it possible to complete a flow balance and get at a delta Q by subreach that suggest a net gain (positive) or loss (negative) due to groundwater. For two of the sampling events within each watershed, chemical data were also gathered at all discharge locations. Net gain and loss data represent the bulk groundwater exchanges, and these can be combined with ion data to establish mass balances [e.g., *Battle-Aguilar et al.*, 2014; *Pinder and Jones*, 1969].

Time series data from the real time water quality/gaging stations has provided fundamental information regarding short term temporal variability of groundwater influences over time at larger spatial scales via flow balances. By combining smaller spatial scale flow and mass balances with PCA analyses and geological layers, we have developed some simplifying assumptions and methods for identifying a range of gross groundwater gains and losses at these smaller scales. Together, the spatially and temporally variable data sets provide the opportunity to test existing methods for understanding groundwater influences [e.g., *Cook*, 2013; *Kalbus et al.*, 2006]. They also allow for testing and developing new methods that are most appropriate for small/intermediate high-gradient streams and rivers that have unique groundwater systems (e.g., karst areas).

Principal Findings and Significance:

Significant work has been conducted, primarily at the University of Utah, regarding groundwater exchanges in urban settings (*Gabor et al.*, 2017). The focus at USU has been on understanding the groundwater exchanges in the montane portions of the Logan River watershed. In watersheds like the Logan, the karst geology results in shorter groundwater travel times, which alter the dynamics between groundwater and surface water. The Logan River is groundwater dominated, and karst features produce numerous springs and sub-surface flowpaths that vary in size. The complexity of these flowpaths limit methods for determining groundwater exchanges over space and time. By applying a flow balance from the continuous streamflow data, we established estimates of net groundwater inflow or outflow over time and at larger reach scales (Figure 1).

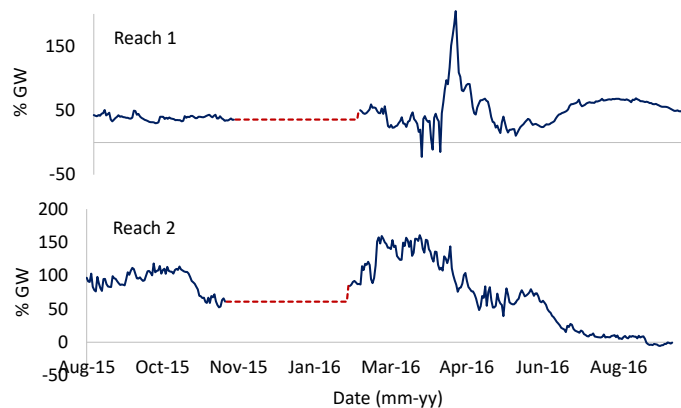


Figure 1. Net groundwater gains or losses for a portion of the Logan River reported as a % of the upstream reach flow.

The small spatial scale flow data are consistent with these findings and show that there are general gains in flow as you move downstream (Figure 2, with the lowest numbers on the x axis being the most downstream point); however, many of these are due to tributaries or inflows. After accounting for these influences, some of the net gains or losses (delta Q) that are due to groundwater influences are positive (gains) and others are negative (losses) (Figure 3).

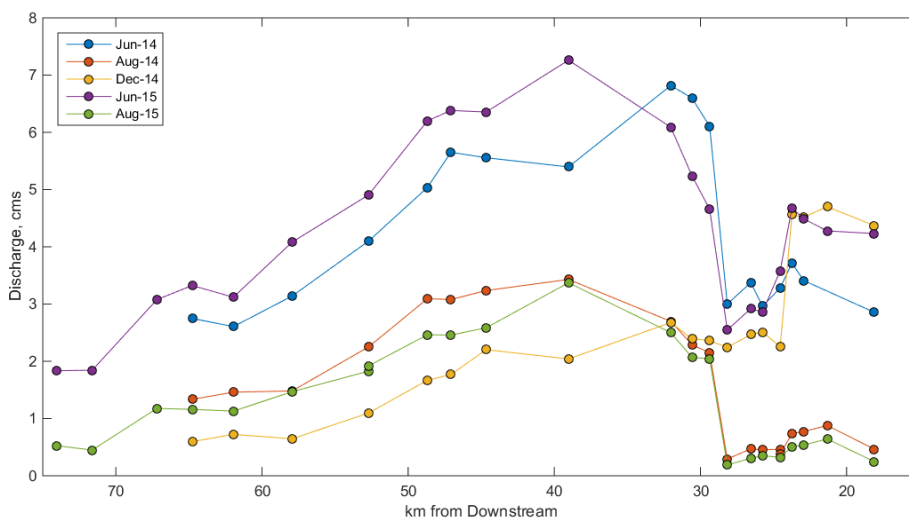


Figure 2. Longitudinal flow for Logan River from the headwaters (Franklin Basin ~75 km) to end of study reach (Mendon Road ~15 km).

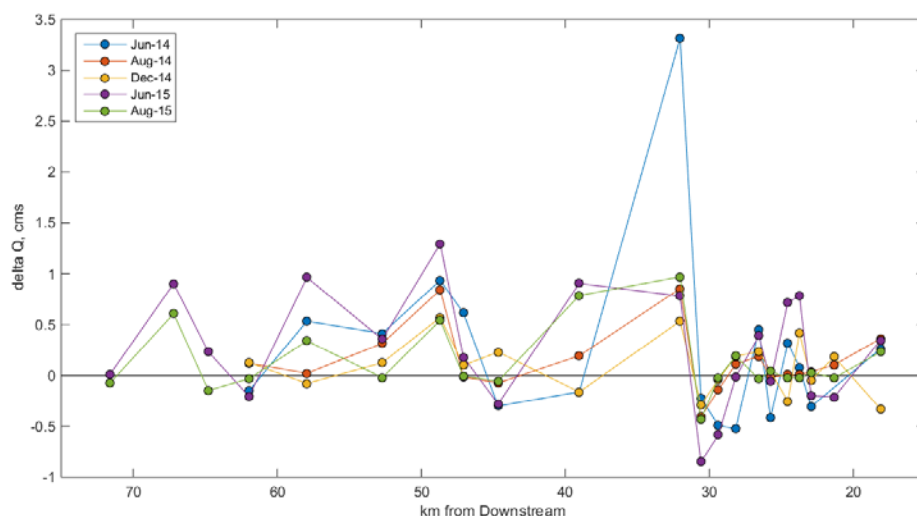


Figure 3. Longitudinal changes in flow for Logan River from the headwaters (Franklin Basin ~75 km) to end of study reach (Mendon Road ~15 km).

By adding the synoptic sampling of ion concentrations (e.g., Figure 4) and flow under different flow regimes at smaller spatial scales (Figure 2 and 3), we have begun to differentiate the contribution between shallow (Figure 6) and deep (Figure 5) groundwater inflows as well as outflows (Figure 5 and 6).

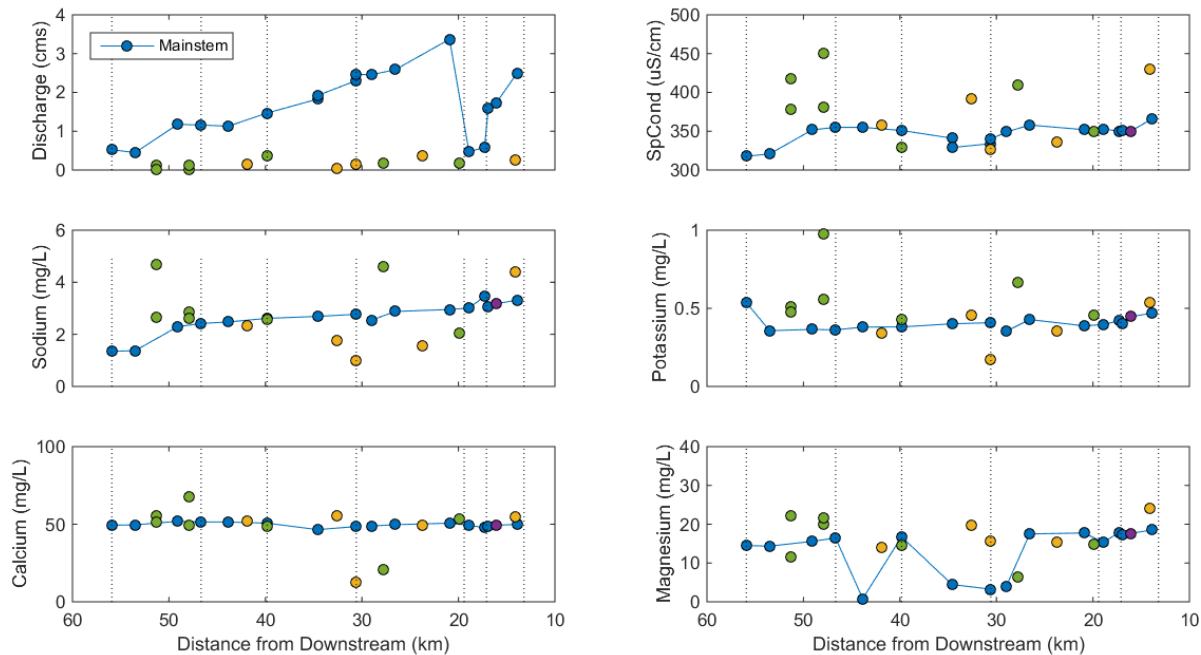


Figure 4. Raw data for Logan River August 2015 sampling sites: mainstem (blue), tributaries (green), and groundwater (yellow).

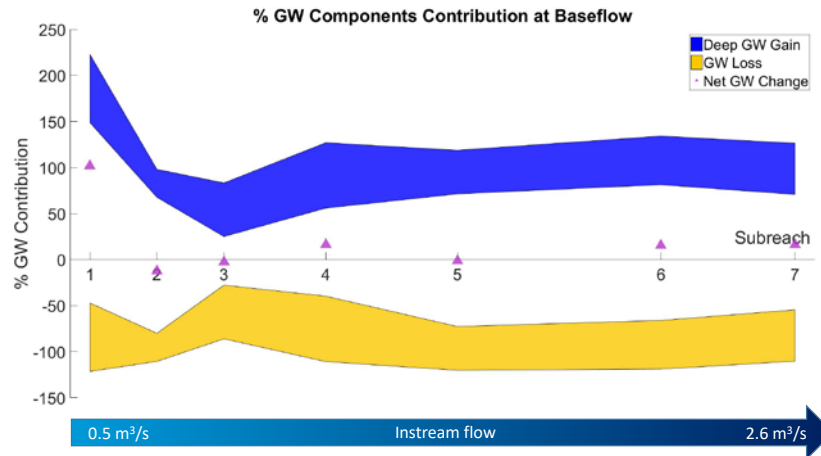


Figure 5. Net groundwater gains or losses (pink triangles) and ranges of possible contributions from deep groundwater (blue) and groundwater losses (yellow) during baseflow conditions (August 2015).

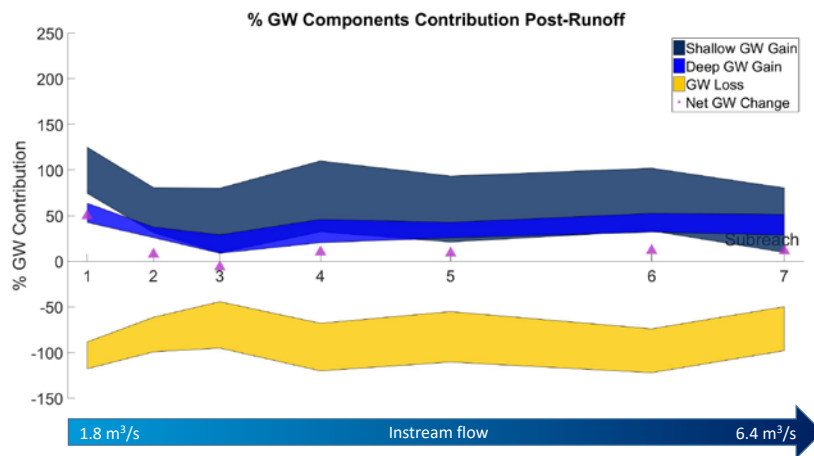


Figure 6. Net groundwater gains or losses (pink triangles) and ranges of possible contributions from deep groundwater (blue, assumed constant from August 2015), shallow groundwater (dark grey), and groundwater losses (yellow) during post runoff conditions (June 2015).

By combining these methods in the Logan River watershed, the larger spatial scale flow balance revealed that the mountainous region of the watershed experienced substantial groundwater gains to the river, in addition to contributions from springs throughout the year (e.g., Figure 1). However, the smaller spatial scale synoptic mass balance analysis revealed that significant groundwater exchanges (both gains and losses) occur during relatively high and low flows (Figures 5 and 6). This approach provides an understanding of groundwater sources, including shallow groundwater contributions that can vary with changes in annual precipitation, deeper groundwater that is expected to be more resilient to a changing climate, and groundwater outflows that will likely remain constant over time. Differentiating between shallow and deeper groundwater flowpaths allows for a better understanding of the resilience of a watershed in a changing climate.

Partners/Collaborators:

State: Additional faculty within the University of Utah and Utah State University involved in the Utah EPSCoR Track 1 National Science Foundation project (iUTAH - innovative Urban Transitions and Aridregion Hydro-Sustainability)

Federal: Matt Miller–United States Geological Survey, Utah Water Center

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Water Strategy Advisory Team: An Assessment of the Envision Utah Process to Improve Water Management

Basic Information

Title:	Water Strategy Advisory Team: An Assessment of the Envision Utah Process to Improve Water Management
Project Number:	2016UT201B
Start Date:	3/1/2016
End Date:	2/28/2017
Funding Source:	104B
Congressional District:	UT2
Research Category:	Water Quality
Focus Category:	Water Use, Irrigation, Management and Planning
Descriptors:	None
Principal Investigators:	Daniel McCool, Marian HubbardRice

Publications

There are no publications.

“Water Strategy Advisory Team: An Assessment of the Envision Utah Process to Improve Water Management (104B)”

Professor Daniel McCool and Marian Rice
2016UT201B

April 12, 2017

Problem and Research Objectives:

Utah is facing unprecedented water challenges. The state is expected to double its population by the year 2050. Climate change is expected to reduce supply. A growing recreation economy is demanding its share of water. Energy production is using dramatically more water than in the past. In October, 2013, the governor of Utah created a “Water Strategy Advisory Team” (WSAT) to assist the state in developing a strategy to “develop a 50-year water plan for Utah.” Specifically, the Team was charged with these tasks:

- Solicit and evaluate potential water management strategies;
- Frame various water management options and the implications of those options for public feedback; and
- Based on broad input, develop a set of recommended strategies and ideas to be considered as part of the 50-year plan (Herbert 11 Oct. 2013).

The WSAT was part of a broader effort administered and facilitated by Envision Utah, a nonprofit public-private partnership, called “Your Utah, Your Future” to plan for the future needs of the state. Envision Utah created advisory teams for eleven major issues; water proved to be the most contentious (Envision Utah 2015).

The WSAT approach to water planning was novel and innovative, and it sent a clear message to the public that Utah needs to plan carefully to meet its future water needs. The team brought together a very diverse group of 38 water managers, elected officials, special interest groups, water attorneys, and academics. The goal was to collaboratively develop a set of goals and priorities for future water policy (Envision Utah 2013a). At the initial meeting, the governor’s representative established four principles to be addressed:

1. Conservation
 2. Maintenance of current infrastructure
 3. Planning for population growth
 4. The need for innovation
- (Envision Utah 2013b).

The WSAT met approximately ten times, and produced a series of process documents such as: “Baseline Assumptions,” “Policy Questions, Issues, and Methods,” “M&I Water Scenarios,” and “Key Policy Questions.” A public survey was conducted in 2014 that presented five pre-set water scenarios (Envision Utah 2014). The final results of the survey were released in August, 2015.

Conceptual Framework

The research will assess the extent to which the Water Strategy Advisory Team met its objectives, and assess its value as a template that could be used by other states and jurisdictions. The WSAT process will be examined within the framework of Integrated Water Resources Management (IWRM), which places great value on collaborative decision-making and a holistic approach to water planning (U. S. Army Corps of Engineers 2014; Conradin 2010). Shabman and Scodari note that “the concept of IWRM is being advocated as a better way to approach the challenges of 21st Century water management” (2012: 1). IWRM focuses on the coordinated and systemic development, management, protection, and preservation of water and associated natural and human resources in order to maximize human welfare, preserve the ecosystem that maintains all life, and do so in a manner that is fair and just to all natural and human communities (Lenton and Muller 2009; United Nations 2012;).

Methodology:

This study will employ a methodology known in the social sciences as “qualitative methods,” with a specific application known as “policy assessment.” The qualitative methods approach is widely employed in the social sciences, humanities, and other fields such as public health (Denzin and Lincoln 2000, 2011; Consortium on Qualitative Methods 2015). It is especially useful in Political Science when analyzing complex, on-going policy problems (Lamont and White 2009; Bennett, Barth, and Rutherford 2003). Basic policy assessment consists of four steps of qualitative research:

1. Identify the objectives of the policy.
2. Assess the extent to which those objectives have been achieved.
3. Explain why the objectives have/have not been achieved.
4. Recommend ways to improve the achievement of policy objectives (Patton, Sawicki, and Clark 2012).

This research will perform all four of those steps for the WSAT process.

The proposed study, relying on IWRM as a framework for analysis, will attempt to answer the following questions:

1. Was the WSAT collaborative, fair, and open?

2. Did the WSAT take a systemic, holistic approach to water resources management?
3. Did the WSAT focus on the interdependency of water resources and other natural resources?
4. Did the WSAT balance social, economic, and environmental goods and services?
5. Did the WSAT recommend a bottom-up, stakeholder-driven process rather than a top-down approach to resolving water conflicts?
6. Did the WSAT recommend a comprehensive, multi-dimensional approach to problem-solving?
7. Did the WSAT balance short-term gains with long-term impacts?
8. Did the WSAT consider inclusivity and equality for all stakeholders and segments of society in the development and administration of water policy?
9. Did the WSAT process, as facilitated by Envision Utah, improve water planning and help prepare Utah for future water demands?
10. What is your overall assessment of the WSAT and the final report issued by Envision Utah?

We will obtain answers to these questions by accessing five sources. First, we will develop a questionnaire that will be sent to all 38 members of the WSAT, asking each team member to evaluate the WSAT experience by answering the ten questions posed above. Second, we will send the same questionnaire to a selection of water stakeholders who were not on the WSAT; this will include water managers, interest groups, elected officials, academics, and water attorneys, in order to assess their opinions of the WSAT effort. If we obtain a sufficient sample size for both the WSAT and non-WSAT respondents, we will perform a series of quantitative and qualitative comparisons between the two. Third, we will conduct in-person interviews with the three co-chairs of the WSAT, and the employees of Envision Utah who facilitated the process. Fourth, we will evaluate all of the written material that was produced by the process, including the final report. And fifth, we will use secondary sources such as articles, published research, and government reports/analyses that were used by the WSAT during its deliberations or were referenced or utilized by Team members.

Principal Findings and Significance:

When the application was submitted for the USGS grant, it was assumed the Water Strategy Advisory Team (the "WSAT") had completed its work without issuing a final report. No meetings had been held for many months, there was no follow-up, and we had heard that the whole process had been so contentious that it had been abandoned. Thus, the fall semester of 2016 appeared to be the perfect time to do a post-mortem assessment of the process. However, the three co-chairs of the WSAT produced a draft final report September 2016. Due to the long period of no communication, the draft report came as a surprise to the members team listed above. The submission of the draft report sparked controversy for the members as well as the public. Due to this, the governor and his environmental advisor realized that more work was needed to produce a balanced report that could gain the acceptance of most of the WSAT members.

In January 2017 the co-chairs established sub-committees to draft various portions of a revised final report. This included an ambitious schedule; however, the members stated they need more time than the schedule allowed. As of the date of this progress report, the sub-committees are still in the process of drafting the revised final report. However, it is estimated the final report will be completed in the next six months. The majority of the research for this study will come after the issuance of the final report. This entails a questionnaire, sent to all WSAT members, as well as interviews with water leaders both within and outside the WSAT.

WaterMAPS™ for Promoting Urban Landscape Water Use Efficiency

Basic Information

Title:	WaterMAPS™ for Promoting Urban Landscape Water Use Efficiency
Project Number:	2016UT203B
Start Date:	3/1/2016
End Date:	2/28/2017
Funding Source:	104B
Congressional District:	UT1
Research Category:	Social Sciences
Focus Category:	Management and Planning, Water Use, Conservation
Descriptors:	None
Principal Investigators:	Joanna EndterWada, Roger Keith Kjelgren

Publications

There are no publications.

WATERMAPS™ FOR PROMOTING URBAN LANDSCAPE WATER USE EFFICIENCY

2016UT203B

Joanna Endter-Wada and Roger Kjelgren

Problem Description

Living with aridity, responding to drought, and adapting to climate change are critical challenges in the Intermountain West generally, but these are particularly pressing issues for the state of Utah. From 2000–2010, Utah was the second fastest growing state (23.8% growth) as well as the second most arid state, and contained two of the fastest growing metropolitan statistical areas (MSAs) in the nation, with St. George ranking second in rate of growth (52.9%) and Provo-Orem ranking sixth (39.8%) (Mackun and Wilson 2011). Understanding patterns of urban water use and preparing for drought have been priority issues in state water planning (UDWR 2003, 2007, 2008, 2010a, 2010b). In an address at the Utah Water Users Workshop in St. George, Utah on March 20, 2013, Governor Gary Herbert emphasized that water is the most important issue for the state of Utah because it underpins all other state planning. The governor laid out four principles for water policy and planning (conservation, maintenance of current water infrastructure, the need to plan for future water needs, and the need for water-related innovations), and he appointed a committee of top water officials who conducted a state-wide water assessment.

Landscape water conservation is being prioritized in Utah and throughout the U.S. West as an important urban water demand management strategy, particularly in areas where outdoor watering uses a significant percentage of municipal water supplies (Mayer et al. 1999; Western Resource Advocates 2007; UDWR 2003; St. Hilaire et al. 2008). The two basic approaches to landscape water conservation are (1) to promote improved irrigation management on existing landscapes that are being overwatered and (2) to promote transition of vegetation to low-water use plant varieties, particularly native species in arid regions. Policies and programs designed to promote landscape water conservation include voluntary and mandatory measures structured to provide education, financial incentives, and technical assistance to encourage behavior change and adoption of new water use technologies and practices. The ability to test the efficacy of these various approaches, however, has been hampered by difficulties involved in isolating changes in water use attributable to water conservation interventions from changes due to many other factors affecting landscape water use patterns, particularly climate impacts on water use and varying residential occupancy due to human population mobility.

Research Objectives

This research addresses the issue of landscape watering in urban systems and the dynamic interactions of people, water applied through irrigation systems, and urban vegetation. The research has practical water management applications. Research results can aid cities to assess the appropriateness of landscape water use relative to landscape water need, to monitor landscape water use change and determine its causes, and to analyze how landscape water use and conservation fit into the overall and long-term management of urban water supply systems.

Overarching Research Objective: To further develop WaterMAPS™ and extend applied research in urban landscape water use analysis, assessment, monitoring, and information provision to promote conservation of water in municipal culinary and pressurized secondary water systems and to aid cities in water conservation policy formulation, planning efforts, and program development.

Specific Research Objectives:

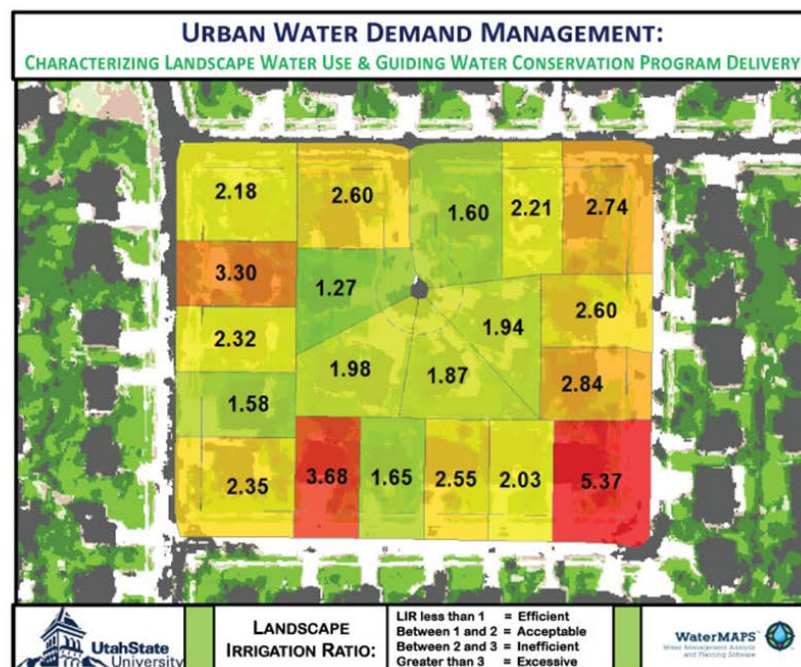
- 1) Refine and extend the approach for analyzing geographic site and human characteristics shaping spatial and temporal patterns of urban landscape water use in order to examine how people respond to climatic, ecological, political and social contexts in their use of municipally-supplied water;
- 2) Establish metrics, benchmarks, and policy prescriptions for appropriate landscape water use capable of being implemented in water management contexts;
- 3) Explore various approaches for scaling up from parcel-level analysis to larger spatial scale analyses (e.g. neighborhood, area, and community analyses) aimed at identifying broader patterns of water use across a city or service area but grounded in parcel-level empirical data;
- 4) Develop techniques for conducting a variety of temporal analyses at different grains of periodicity (e.g., seasonal, monthly) aimed at characterizing and explaining the dynamics of change in urban landscape water use.

Methodology

This project builds on and extends research analyzing landscape water use conducted by Endter-Wada, Kjelogren, and colleagues (Endter-Wada et al. 2008; Glenn et al. 2015; Kilgren et al. 2010; Farag et al. 2011; Welsh et al. 2012). This USU team has developed an analytic approach and a software package to quantify landscape water use at the parcel level across an entire service area. This approach produces a site-specific seasonal Landscape Irrigation Ratio (LIR) that compares estimated landscape water use (total metered use minus estimated indoor use over an irrigation season) to estimated landscape water need (based on amount of area

in different landscape cover types derived from the classification of remotely-sensed airborne multispectral imagery and from localized reference evapotranspiration rates modified by relevant landscape factors). This approach provides a standardized metric for comparisons between various locations (spatial analysis) and between years at the same location (temporal analysis).

WaterMAPS™ (Water Management Analysis and Planning Software) automates this landscape water use analysis and graphically displays landscape irrigation ratios by locations (color coded by ranges the water manager can define) across an entire city or service area (see figure). It does so by integrating GIS data, remotely-sensed aerial multispectral landscape imaging, weather data, municipal water billing data, and property information into a dynamic software application. One of the key features of the software is its ability to combine multiple datasets (property records, water consumption, weather, landscape characteristics), ultimately providing a location's water consumption history capable of being joined with GIS data. In the process, the software resolves issues problematic with billing data from an analytic standpoint, such as meter changes, multiple meters, and residential mobility, producing complete and temporally continuous data representing metered water use for each location. This analytic approach enables spatial and temporal analyses of urban water use patterns.



Principal Findings and Significance

The value and utility of WaterMAPS™ depends on (1) the validity and reliability of the data used to calculate Landscape Irrigation Ratios, which is the ratio of the amount of water applied to landscapes compared to the amount of water landscapes need; and (2) the nature of the analyses conducted using LIRs. The WaterMAPS™ development team made specific refinements to the software application that capitalize on the availability of new sources of data for its calculations, such as smart meter data at finer time scales. The WaterMAPS™ software code was rewritten to be more efficient. Other refinements to the software include:

- 1) *Landscape Water Need.* New algorithms for estimating water requirements were added that provide the user with options to incorporate a soil moisture balance routine and real-time ET estimates or historical ET averages to calculate water budgets. These options offer water providers with choices that can be aligned to match other conservation programs or policy goals. For example, using historical ET averages to calculate the water budget in WaterMAPS™ matches the budget provided to Water Check Program participants in their water schedule and provides consistent information across programs to water users. If a water provider wants to define the maximum capacity to conserve, we would use real-time ET values and the soil moisture balance routine to calculate LIRs. Preliminary data show this calculation captures, on average, 30% greater capacity to conserve when compared to historical ET averages.
- 2) *Estimating Urban ET.* We are collaborating with the Utah Climate Center to investigate approaches for better estimating urban ET for use with WaterMAPS™. The Climate Center is developing a tool that will provide better *urban* ET estimates by zip code than those currently available. The data are accessible through an API, and we have conducted user testing for the Climate Center to work out any issues. Once the tool is made publicly available, anyone interested in analyzing their water use with WaterMAPS™ will have access to curated urban ET data.
- 3) *Database Infrastructure.* The revised software stores the data in relational databases and HDF5 datasets rather than ESRI Shapefiles, which provides for faster performance. In addition, the data preparation routine used to group park strips with associated parcels has been improved and is considerably faster than the former version. Currently, a web interface for the software is being built to provide WaterMAPS™ services to individuals, property managers, or water providers.
- 4) *Estimating Indoor Water Use.* Progress was made on this task during the project period. We investigated ways this issue has been approached by other researchers and how we can refine our technique to estimate indoor water use on a real-time basis. Currently, WaterMAPS™ uses winter metered data at a location as an estimate of indoor use (with various calculations to produce an estimated daily

amount). We have written a new algorithm to interpolate daily water use from monthly meter readings. The frequency of metered data is improving with new AMI systems, which provides greater opportunity to incorporate more refined indoor estimates. We continue to work on this software improvement as data becomes available.

5) *Landscape Classification*. We are working on techniques to verify identification and classification of low-water use landscapes from aerial imagery in collaboration with the USU RS-GIS Laboratory. As these landscapes become more widely adopted in the urban environment, we want to take them into account in water budget calculations. Two new WaterMAPS™ projects that we have are providing opportunities to look at this issue more closely in connection with ground observations.

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Information Transfer Program Introduction

The individual research projects documented in the Research Project section of this report have information and outreach components integrated within them. These include research findings published in the technical literature and findings and water management models and tools provided on the web pages of the Utah Center for Water Resources Research (UCWRR) and individual water agencies. Beyond this, Information Transfer and Outreach activities through the UCWRR, the Utah Water Research Laboratory (UWRL), and Utah State University (USU) have had an impact on technical and economic development in the State of Utah. As part of the UCWRR outreach activities supported by USGS 104 funds, we continue to assess and experiment to improve the efficiency and effectiveness of UCWRR outreach activities. Faculty engage in regular meetings with State of Utah water resources agencies, including the Department of Environmental Quality (DEQ), the Department of Natural Resources (DNR), the State Engineer's Office, and numerous municipal water supply and irrigation companies to provide assistance in source water protection, on-site training, non-point source pollution management, technology transfer, development of source water protection plans (SWPPs), and efficient management of large water systems within the context of water-related issues in Utah. UCWRR staff, through the facilities at the UWRL, provide short courses both on- and off-site within the State of Utah, regionally, and internationally. Generally offered from one to five days in duration, short courses are tailored to meet the needs of the requestor. The following is a partial list of information transfer and outreach activities, short courses, and field trainings that involve UCWRR staff.

Principal Outreach Publications

Principal outreach items include our website and newsletter, along with other reports.

The Water bLog newsletter, which is published semi-annually, highlights a small selection of research projects and their findings from UCWRR affiliated faculty and students. Additional publications from the UCWRR and UWRL appear regularly as technically-reviewed project reports, professional journal articles, other publications and presentations, theses and dissertation papers presented at conferences and meetings, and project completion reports to other funding agencies.

Short Courses

None of the short-courses conducted were related to USGS funded projects in FY 2016.

Information Transfer in Support of the Utah Center for Water Resources Research (UCWRR)

Basic Information

Title:	Information Transfer in Support of the Utah Center for Water Resources Research (UCWRR)
Project Number:	2016UT202B
Start Date:	3/1/2016
End Date:	2/28/2017
Funding Source:	104B
Congressional District:	UT1
Research Category:	Not Applicable
Focus Category:	Education, None, None
Descriptors:	None
Principal Investigators:	R. Ivonne Harris, Carri Lyn Richards

Publications

1. UCWRR, 2016, The Water bLog, Utah Center for Water Resources Research, Vol. 6(1).
<http://uwrl.usu.edu/research/newsletters/waterblog-2016-jun.pdf>
2. UCWRR, 2016, The Water bLog, Utah Center for Water Resources Research, Vol. 6(2).
<http://uwrl.usu.edu/research/newsletters/waterblog-2016-nov.pdf>

Information Transfer in Support of the Utah Center for Water Resources Research (UCWRR)

(2015UT198B)

R. Ivonne Harris

Carri Richards

Problem

The Water Resources Research Act of 1964 established the Utah Center for Water Resources Research (UCWRR). The Center is housed at the Utah Water Research Laboratory at Utah State University in Logan, Utah. The UCWRR fosters interdepartmental research and educational programs in water resources, administers Utah's State Water Research Institute Program funded through the U.S. Geological Survey, and provides university-wide coordination of water resources research.

Objectives

As one of 54 water research centers nationwide, the UCWRR supports and promotes responsible and sustainable water resource management and stewardship as the State of Utah works to "*make sure that tomorrow has enough clean water.*" Utah is home to approximately 50,000 miles of rivers and streams and 7,800 lakes, and this water is an essential resource for the economic, social, and cultural well-being of the State of Utah. The Center plays a vital role in the dissemination of information in support of these goals.

A major component of the information transfer and outreach requirements of the UCWRR is the development of appropriate vehicles to disseminate information generated by research projects conducted at the Center. The project provides on-going updates to the UCWRR web page, with information transfer specifically identified as the key objective. The semi-annual newsletters for the Utah Center feature research projects and their findings, water-related activities in the state, and on-going work by researchers affiliated with the Center.

Methods

Web Page

A crucial objective for information dissemination at the UCWRR has been the development of an up-to-date web page, where information can be widely available on the internet. We recently transitioned the UCWRR website to OU Campus as part of the general UWRL website upgrade. Information transfer publications posted on the site include pictures and summaries of on-going projects and other relevant information. With the website upgrade, the web address for the UCWRR has changed to <http://uwrl.usu.edu/research/ucwrr/>. Figure 1 shows an overview of the website content.

Utah Center for Water Resources Research (UCWRR)



The UCWRR is one of 54 state water institutes that were authorized by the Water Resources Research Act of 1964. Housed within the Utah Water Research Laboratory, the Center promotes and coordinates the development of research and instructional programs related to stewardship of water quantity and quality through collaboration with federal, state, and local government and the private sector and furthers the training of water resource scientists and engineers.



Current Water bLog Newsletter

Previous Newsletters

About the UCWRR

The UCWRR actively assists the Utah Department of Environmental Quality (UDEQ), the Utah Department of Natural Resources (UDNR), the State Engineer's Office, all 12 local health departments, and various large water management agencies and conservancy districts within the state with specific water-related problems pertinent to the scope of each.

The UCWRR maintains strong communications and close working relationships with water-related state and local agencies through participation on state boards, activities in conferences and committees, and personal contacts.

Key Objectives:

- Facilitate water research, outreach, design, and testing elements to support student education and citizen training
- Foster interdepartmental research and educational programs in water resources
- Administer the State Water Research Institute Program funded through the U.S. Geological Survey at Utah State University for the State of Utah
- Provide university-wide coordination of water resources research

Mission & Vision

Program Management & Coordination

Research Program & Funding

Past Projects

The Utah Center for Water Resources Research (UCWRR) is located at Utah State University (USU), the Land Grant University in Utah, and is managed by the Director and staff of the Utah Water Research Laboratory (UWRL) at USU. It is one of 54 state water institutes that were authorized by the Water Resources Research Act of 1964. Its mission is related to stewardship of water quantity and quality through collaboration with government and the private sector.

The UCWRR actively assists the Utah Department of Environmental Quality (UDEQ), the Utah department of Natural Resources (UDNR), the State Engineers Office, all 12 local health departments, and several large water management agencies and purveyors in the state with specific water resources problems.

The mission of the UCWRR is to foster scholarship that supports research and education within a university environment, and information transfer and service to external audiences. The research is directed at solving multimedia water-related problems of state, national, and international scopes. The UCWRR works with academic departments at universities in the state and with local, state, and federal water and resources management agencies in planning, conducting, and arranging for research and in generating, transmitting, applying, and preserving knowledge related to water quality and quantity issues and problems. An

Figure 1. UCWRR website at <http://uwrl.usu.edu/research/ucwrr>

Newsletter

The UCWRR continues to publish the semi-annual newsletter, *The Water bLog*, which is published electronically via the UWRL/UCWRR web site at:

<http://uwrl.usu.edu/research/newsletter>.

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UTAH WATER RESEARCH LABORATORY

A-Z Index MyUSU directory

About People Research Environmental Engineering Hydraulic Services Water Resources News Contact

Water bLog Newsletters

The **Water bLog** is the semi-annual newsletter of the Utah Center for Water Resources Research (UCWRR), housed at the Utah Water Research Laboratory (UWRL). Each issue reports on a small selection of current or recently completed research projects and other topics of interest.

Current Newsletter - Nov 2016

[Download PDF](#) | [View online](#)

The Water bLog newsletter
November 2016
Utah Center for Water Resources Research at the Utah Water Research Laboratory

Message from the Director

Welcome!

INSIDE

Research Highlights:

- Computational Fluid Dynamics: optimizing Venturi flow meter design
- Understanding Air Quality Processes and Pollutants: the search for answers and improvements
- Abdulkarem Elhadi: initiating new research to save the air at home in Palestine

In the News:

- Research projects recently featured in local news outlets

Featured Researchers:

- Ronald S. Martin & Zachary Sharp

Other UWRL Publications:

- UWRL Annual Reports
- Research Publications & Reports
- Mineral Lease Fund Reports
- Archival Documents

Figure 2: The Water bLog Newsletter home page (<http://uwrl.usu.edu/research/newsletter>).

The newsletter is disseminated through e-mail to approximately 350 readers. Its main purpose is to highlight research projects and their findings, often which hold interest and value to the State of Utah, as well as nationally and internationally. The current version of the Water bLog newsletter presents stories about venturi meter design using computational fluid dynamics and new approaches to air quality research. Other segments highlight the people behind the research as well as other recent accomplishments by those associated with the Center.

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Other

Other publications from the UCWRR and UWRL appear regularly as technically-reviewed project reports, professional journal articles, other publications and presentations, theses and dissertation papers presented at conferences and meetings, and project completion reports to other funding agencies. A number of these are available in the USU Digital Commons (<http://digitalcommons.usu.edu/water/>) The annual Mineral Lease Funds Report, submitted to the Utah Office of the Legislative Fiscal Analyst, reports on a wide range of research projects ongoing at the UCWRR and UWRL that specifically benefit the State of Utah (<http://uwrl.usu.edu/research/mlf-reports>).

USGS Summer Intern Program

None.

Student Support					
Category	Section 104 Base Grant	Section 104 NCGP Award	NIWR-USGS Internship	Supplemental Awards	Total
Undergraduate	0	0	0	0	0
Masters	2	0	0	0	2
Ph.D.	0	0	0	0	0
Post-Doc.	0	0	0	0	0
Total	2	0	0	0	2

Notable Awards and Achievements

Faculty member Bethany Neilson was named USU College of Engineering Graduate Student Mentor of the Year and USU Civil and Environmental Engineering Graduate Student Mentor of the Year for 2016.

Faculty member Dr. Blake Tullis receive the 2016 Terry L. Hampton Medal from ASDSO. The award is not offered every year, and Dr. Tullis is only the 5th recipient to be so honored. The award recognizes individuals who have made outstanding contributions to dam safety.

Mac McKee, UCWRR Director, was named a Friend of UCOWR at the Universities Council on Water Resources (UCOWR) Annual Conference awards ceremony held this year in Pensacola Beach, Florida. UCOWR recognizes no more than three individuals each year who have “made substantial contributions in time and effort toward the goals of UCOWR.” Mac held the office of UCOWR President twice and served on the board of directors for nearly a decade.

Faculty member R. Ryan Dupont was named USU College of Engineering Undergraduate Research Mentor of the Year for 2016. Dr. Dupont has recently been heavily involved in the use of natural attenuation and bioaugmentation for site remediation and in the use of DNA probes for describing microbial community response to engineering management controls applied for site remediation.

Faculty member R. Ryan Dupont and several other UCWRR and USU faculty members received a grant to study the feasibility of harvesting stormwater to recharge underground aquifers as part an EPA grant that totaled \$3.3 million and is split between five proposals nationwide.

Publications from Prior Years

1. 2013UT189B ("Quantification of Water Quality Improvements Through the 900 S Oxbow Restoration and Stormwater BMP Renovation Project") - Articles in Refereed Scientific Journals - Borecki, M.R.; J.E. McLean; R.R. Dupont, 2016, Bioaccumulation of Copper, Lead, and Zinc in Six Macrophyte Species Grown in Simulated Stormwater Bioretention Systems, *Journal of Environmental Management*, 166:267-275.
2. 2013UT189B ("Quantification of Water Quality Improvements Through the 900 S Oxbow Restoration and Stormwater BMP Renovation Project") - Articles in Refereed Scientific Journals - Borecki, M.R.; J.E. McLean; R.R. Dupont, 2017, Nitrogen and Phosphorus Mass Balance, Retention and Uptake in Six Plant Species Grown in Stormwater Bioretention Microcosms, *Ecological Engineering*, 99:409–416.
3. 2011UT156B ("Analyzing the Spread of *Phragmites Australis* Over Short Time Scales Using Spatial and Genetic Tools") - Articles in Refereed Scientific Journals - Kettenring, K.M., K.E. Mock, B. Zaman, and M. McKee, 2016. Life on the edge: reproductive mode and rate of invasive *Phragmites australis* patch expansion, *Biological Invasions*, 18:2475-2495.
4. 2007UT87B ("Two-Zone Temperature and Solute Model Testing and Development in the Virgin River") - Articles in Refereed Scientific Journals - Schmadel, N. M., J. Heavilin, B.T. Neilson, A. Wörman, 2016, Isolating parameter sensitivity in reach scale transient storage modeling. *Advances in Water Resources*, 89, 24-31, doi:10.1016/j.advwatres.2015.12.020
5. 2014UT193B ("Influence of Groundwater/Surface Water Interactions in High Gradient Mountain Streams") - Articles in Refereed Scientific Journals - Constantz, J.; R. Naranjo; R. Niswonger; K. Allander; B. T. Neilson; D. Rosenberry; D. Smith; C. Zamora; D. Stonestrom, 2016, Water and heat exchanges near natural vs. channelized stream mouths, *Water Resources Research*, 52, 2157-2177, doi:10.1002/2015WR017013.
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7. 2014UT193B ("Influence of Groundwater/Surface Water Interactions in High Gradient Mountain Streams") - Articles in Refereed Scientific Journals - Niswonger, R.; R. Naranjo; D. Smith; J. Constantz; K. Allander; D. Rosenberry; B. Neilson; M. Rosen; D. Stonestrom, 2017, Nutrient Processes at the stream-Lake interface for a channelized vs. unmodified stream mouth: Implications for cultural-climatic eutrophication in a sub-alpine setting. *Water Resources Research*. 53, doi:10.1002/2016WR019538.